Continuous Fetal Tissue pH Monitoring in Labor

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Since the 1960's there has been enormous progress in the study of the intrauterine patient. Among the major developments was the surveillance of the fetus by fetal scalp blood sampling, relating fetal scalp blood pH to fetal well-being in labor. Another significant development was the concentration of interest in intrapartum monitoring of the fetal heart rate by electronic means. An extensive literature on the significance of fetal heart rate patterns in association with uterine contractions in labor now exists. Such patterns are interpreted for the diagnosis fetal distress, and are combined with the biochemical data obtained by fetal scalp blood sampling. Ominous fetal heart rate patterns and low fetal scalp blood pH have been shown to correlate with poor perinatal outcome. In the United States, the accepted procedure is to obtain serial fetal scalp blood pH readings whenever a suspicious fetal heart rate pattern is found. Fetal acidosis is considered to confirm the fetal jeopardy suggested by the abnormal heart rate pattern.

The pathophysiology of fetal acidosis is based on maternal-fetal exchange through the placenta. Given normal maternal acid-base balance, fetal acidosis is the result of severe feto-placental hypoxia. Conditions such as fetal bradycardia, umbilical cord compression, placental insufficiency, abnormalities of labor, and maternal disease states all may produce fetal hypoxia resulting in falling tissue and blood pH. When acidosis is not present, the fetus is considered to be in good condition, even when hypoxia is present. Conservative management of the patient is indicated, and cesarean section may be avoided in cases where fetal acidosis is absent, despite an abnormal fetal heart rate pattern. The usefulness of the combined approach of biophysical and biochemical monitoring has been limited by the problems in fetal scalp blood sampling. The procedure is relatively difficult, the data are intermittent, and repeated scalp incisions may be hazardous to the fetus, and uncomfortable for the parturient. However, technology has advanced sufficiently to overcome this series of

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difficulties. Stamm (1) has developed a miniature glass pH electrode capable of measuring subcutaneous tissue pH, and has proved its effectiveness in the neonate. Utilizing this electrode a continuous fetal pH can be measured and correlated with the information obtained by a fetal heart monitor. The continuous recording of fetal heart rate and fetal tissue pH offers intensive surveillance of the high risk fetus in labor. The pH electrode utilized in our studies is a miniature silver: silver chloride electrode with potassium chloride reference solution. The glass tip extends into the fetal scalp to a depth of 3-4 mm. The pH electrode is secured in place by a specially designed double spiral ECG electrode. The double spiral electrode picks up the fetal electrocardiogram for fetal heart rate determination. This electrode, attached to a fetal monitor, allows the continuous display of the tissue pH every 15 seconds along with the fetal heart rate and uterine contractions (2,3,4). The technique was applied only in high risk cases, where fetal scalp blood sampling was clinically indicated. Informed consent was obtained, and the scalp capillary blood sample collected when the cervix was at least 4 cm dilated, the membranes ruptured, and the vertex engaged. Once the fetal scalp blood sample was accomplished, the tissue pH apparatus was attached and connected to the fetal monitor. Subsequently, intermittent scalp blood samples were obtained to verify the accuracy of the continuous tissue pH readings. Finally, after delivery, umbilical artery blood pH was measured, and compared with the last tissue pH reading, when it was obtained within one half hour of delivery.

Several problems were encountered in these studies. An incision approximately 2 mm in depth must be made in the scalp to allow placement of the glass pH electrode. When this scalp incision is too large, it allows motion of the electrode, with entry of air into the scalp incision. Poor attachment of the electrode will also allow for errors, producing excessive motion of the pH sensor and false variations in the pH. Moreover, this motion increases the risk of trauma to the scalp. A further problem is the accumulation of tissue protein on the glass electrode after repeated use, again producing inaccurate readings. The problem of infection of the

neonatal scalp occurred in 4% of cases. Since initiating a procedure of washing the scalp with an antiseptic, there have been no further scalp infections. Finally, there is the risk of breakage of the glass electrode, which did not occur in our series.

Continuous tissue pH monitoring was attempted in 150 cases over the past four years, with successful application of the electrode in 80%. When the data were plotted to compare fetal scalp blood and tissue pH by linear regression analysis, the correlation coefficient was 0.8, a statistically significant positive correlation (p less than .001). When linear regression analysis was utilized for umbilical artery and last tissue pH data the correlation coefficient was r=0.72 for a statistical significance of p less than .001 as well. The standard error of the estimate was .0354, within the range seen for scalp blood sampling alone. The average tissue pH during the fetal heart rate change was correlated with the relative seriousness of the fetal heart rate pattern. The lowest average tissue pH was seen during decelerations with late component, and during fixed tachycardia, while the highest was seen during accelerations. These observations are confirmed when the data are viewed differently, considering the effect of fetal heart rate changes on tissue pH in individual cases. The tissue pH changes reflect the relative seriousness of the fetal heart rate pattern, with 93% of the cases of decelerations with late component showing a fall in tissue pH, compared with none in the benign patterns of acceleration and moderate bradycardia. The pattern of moderate bradycardia was of particular interest. Moderate bradycardia is defined by Hon (5) as a baseline fetal heart rate of 100-119 beats per minute. Utilizing continuous tissue and fetal scalp blood pH monitoring this pattern has been shown to be benign. It indicates fetal head compression with posterior or transverse positions of the vertex in the large majority of cases. It is not associated with acidosis, and is not related to fetal distress (6,7).

The continuous tissue pH technique has been most useful in studying the problem of variable fetal heart rate deceleration patterns. The continuous technique overcame the difficult problem of applying inter-

mittent scalp blood sampling to a rapidly changing and transient fetal heart rate pattern. A study of 89 cases of variable deceleration was carried out. These were classified into two groups, 47 with no late component and 42 with a late component. A late component is defined as a deceleration of variable shape which began at least 20 seconds after the contraction, or recovered to baseline after the contraction was over, or both. This pattern of variable with late component, was associated with a fall of tissue pH during the deceleration in 90% of the cases associated with a late recovery of the fetal heart rate, and in 31% of the cases with late onset of the deceleration only. Variable decelerations without late component had an 8% incidence of falling tissue pH during or after the deceleration pattern. When the pattern was variable with late recovery, the average fall in tissue pH was 0.07 pH units. When the variable deceleration pattern associated with late recovery persisted until delivery, there was a 56% incidence of Apgar scores below 7. Variable decelerations with no late component had an 8% incidence of low Apgar scores. Thus, the pattern of variable deceleration with a late component is a significant indicator of fetal stress. Variable decelerations without a late component are now understood to be benign. Variable decelerations alone do not indicate fetal distress or require prompt delivery. When the pattern is variable with late recovery, there is a strong likelihood of progressive fall in the fetal pH, and a significant risk of poor perinatal outcome as evidenced by low Apgar score. Therefore, for clinical management, one can separate the relatively benign variable deceleration pattern from that of variable deceleration with a late component(8).

The studies carried out up to the present time indicate that tissue pH is correlated with scalp capillary blood pH but averages approximately .04 pH units lower in both the human fetus in labor and in the neonate. Changes in the fetal heart rate which affect tissue pH do so within 2-3 minutes, a time span which is satisfactory for clinical use. There is a clear relationship between tissue pH changes and fetal heart rate patterns which conforms to the expected pathophysiology of the intrapartum fetus. Thus, the greatest incidence of falling tissue pH is

seen with decelerations with late components (93%), while the average tissue pH is lowest during the most pathological patterns. Although the pathophysiology of the tissue pH response is not clearly understood, it appears to follow current concepts of fetal stress and distress. Therefore, potential clinical use must be considered for the 1980's. Clinical use does require fetal scalp blood sampling for confirmation of the tissue pH results. The use of continuous measurement permits trend monitoring of tissue pH as another modality for clinical interpretation of fetal heart rate patterns. The continuous application of the tissue pH electrode avoids the repetitive scalp incisions necessary when following a potential case of fetal jeopardy very closely. The accurate diagnosis of fetal distress, and avoidance of unnecessary cesarean sections, are possible benefits of this technique.

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